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Blood clot parameters: Prejudgment of fibrinolysis in thromboelastography

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ABSTRACT

Background: Thromboelastography (TEG) is a physical method to simulate the whole process of coagulation and fibrinolysis in the human body environment, and then it also can quickly determine whether patients with hypercoagulable, low coagulation, fibrinolysis or other symptoms. The first step in the diagnosis is based on two parameters: Estimated percentage of lysis (EPL) or the Lysis at 30 min (LY30). These two parameters are used to determine whether the sample has fibrinolysis. However, the determination of LY30 takes a long time, although EPL can reflect real-time fibrinolysis, sometimes the secondary fibrinolysis is not obvious.

Materials and methods: We have an extensive database of results from TEG of fibrinolysis and healthy whole blood (WB). These results were generated using citrated WB, followed by the addition of $CaCl_2$, to initiate clot formation.

Results: According to the characteristics of fibrinolysis, a new parameter clot retention time (CRT) was proposed to predict the status of fibrinolysis, and the normal range of the parameters was obtained in this paper.

Conclusion: It is essential for the clinician to determine the fibrinolytic and ultimately contribute to the treatment of patients. We believe this parameter will add to the standardization of TEG parameters. The new parameter will also shorten the measurement time of non-fibrinolytic samples, which has definite physiological and pathological significance.

1. Introduction

Thromboelastography (TEG) can continuously observe the whole process of blood coagulation [1–6]. That is from the blood began to coagulation, solidification and fibrinolysis of the dynamic changes, which including the rate of prothrombinase, thrombin and fibrin formation, the state of fibrinolysis and the elasticity of clot [7–12]. Clinician determine the condition of patients is based on the scope of TEG parameters, the exclusion of fibrinolysis which on the basis of the value of Estimated percentage of lysis (EPL) or the Lysis at 30 min(LY30) is the first step [13]. Estimated Percent Lysis (EPL) is the estimated percent lysis at 30 min after MA. This parameter is computed 30 s after the MA, and is continually updated until 30 min after MA is reached. The LY30 parameters measure percent lysis at 30 min after Maximum Amplitude (MA) is reached. According to the definition of these two parameters, the value of LY30 must be 30 min after the TEG tracing reaches Maximum Amplitude [13–15]. EPL can obtain real-time value after Maximum Amplitude, but it is not obvious for secondary fibrinolysis. Therefore, the judgment of the fibrinolytic process is still flawed. To achieve accurate judgment, it must be done for a long time until the LY30 value is reached. TMA time (Time to Maximum Amplitude) combines the rate of clot development from the start of a sample run until the clot reaches its maximum strength. When a sample's TMA time is particularly long, you need to wait an hour or even longer to make a complete judgment, this will affect the doctor to make a timely judgment of the disease and will delay the treatment time. This paper presents a new parameter to predict the situation of fibrinolysis and add the clot lysis parameters to description of TEG tracing.

2. Materials and methods

2.1. Blood samples

Whole blood was collected from patients with physical examination, which include healthy samples and fibrinolysis samples were selected. A clinician identified the patients, and samples were collected under very strict aseptically conditions.

2.2. Ethical statement

A written form of informed consent was obtained from all blood donors or family members who donate blood.

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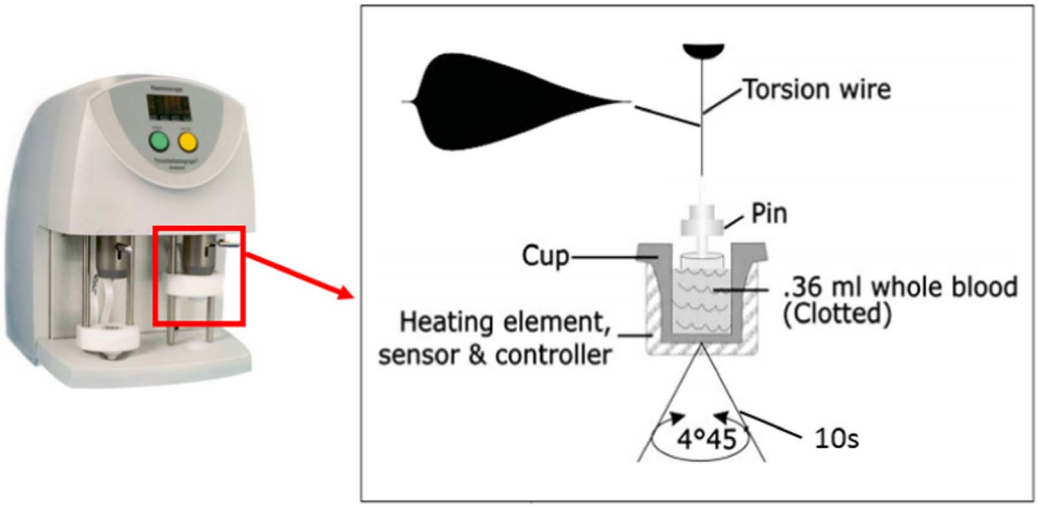

Fig. 1. TEG design and principles of operation.

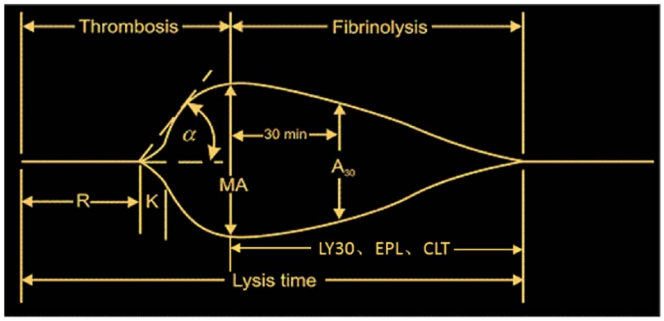

Fig. 2. TEG tracing parameter.

Table 2
TEG lysis parameters.

Clot lysis parameters	Explanation
A30/A60	The A30 and A60 parameters are the amplitudes of the TEG tracing at 30 min and 60 min after MA is measured.
LY30/LY60	The LY30 and LY60 parameters measure percent lysis at 30 min and 60 min after MA is reached.
EPL(estimated percent lysis)	Estimated percent lysis (EPL) is the estimated percent lysis at 30 min after MA. This parameter is computed 30 s after the MA, and is continually updated until 30 min after MA is reached.
CLT(Clot Lysis Time)	CLT is the elapsed time between MA and 2 mm amplitude or less post MA.

2.3. TEG principles and parameters

The TEG analyzer measures the clot's physical property by the use of a special stationary cylindrical cup that holds the blood and is oscillated through an angle of 4°45′ (Fig. 1). Each rotation cycle lasts 10 s. A pin is suspended in the blood by a torsion wire and is monitored for motion. The torque of the rotating cup is transmitted to the immersed pin only after fibrin-platelet bonding has linked the cup and pin together. The strength of these fibrin-platelet bonds affects the magnitude of the pin motion, such that strong clots move the pin directly in phase with the cup motion. Thus, the magnitude of the output is directly related to the strength of the formed clot. As the clot retracts or lyses, these bonds are broken and the transfer of cup motion is diminished. The rotation movement of the pin is converted by a mechanical–electrical transducer to an electrical signal which can be monitored by a computer [16,17].

The resulting hemostasis profile is a measure of the time it takes for the first fibrin strand to be formed, the kinetics of clot formation, the strength of the clot (in shear elasticity units of dyn/cm2) and dissolution of clot. Fig. 2 shows the Schematic diagram of the TEG parameters [13]. The detailed definition of these parameters is shown in Table 1 and Table 2 [13,18,19].

2.4. Accuracy analysis of fibrinolysis

The measurement of LY30 and LY60 is a decrease in area after 30 (or 60) minutes of MA. EPL is the degree of dissolution after 30 min of MA. The formula is: EPL(%) = 100 ∗ (MA − A30)/MA. When the arrival of MA after 30 min, its value is equal to LY30. To make a precise and timely judgment of the fibrinolysis, we can make an observation on the EPL and LY30 in the samples of fibrinolytic by means of TEG and a corresponding software.

Table 1
TEG Coagulation parameters.

Coagulation parameters	Explanation
R time	The time from the start of a sample run until the first significant levels of detectable clot formation (amplitude = 2 mm in the TEG tracing).
K time	The time from the measurement of R (beginning of clot formation) until a fixed level of clot firmness is reached (amplitude = 20 mm).
α (alpha)	The angle is closely related to K-time, since they both are a function of the rate of polymerization. The angle is more comprehensive than K-time, since there are hypocoagulable conditions in which the final level of clot firmness does not reach an amplitude of 20 mm (in which case K is undefined).
MA (Maximum Amplitude)	Measurement of maximum strength or stiffness (maxi-mum shear modulus) of the developed clot.
A	The A parameter measures the width of the tracing at the latest time point.
TMA(Time to MA)	TMA combines the rate of clot development from the start of a sample run until the clot reaches its maximum strength. This can be described as the time needed to form a stable clot.